Green Lake Water Quality

Monitoring Results
for Water Year 2009 at Green Lake

Green Lake *Photo by Sally Abella*

Prepared for the City of Seattle
by the King County Lake Stewardship Program

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King County

Overview

The King County Lake Stewardship Program (KCLSP) and its predecessor programs have worked with volunteer monitors on Green Lake since 2005 to track water quality in the summer months, which has been of particular interest after the alum treatment of the lake was carried out in 2004 to control phosphorus concentrations in the water column. Two sampling stations in the lake were established in 2005 and measurements were taken at both in the years 2005 – 2008. Beginning in 2009, only one station was monitored for water quality, while some of the year-round physical monitoring occurred from the dock at East Green Lake (Figure 1).

Figure 1. **Station locations**

Green Lake is surrounded by a public park, and car-top boats can be launched at various points around the lake. It has a history of milfoil infestations, for which various eradication efforts have been underway for decades. Green Lake has also been closed to recreation for bluegreen algae blooms and has been treated for nutrient reduction to control algae, including all-lake alum treatments in 1991 and again in 2004.

The most recent treatment had a significant impact on nutrients and immediately improved the water quality of the lake. The 2009 data indicate that this lake is currently low to moderate in primary productivity (lower mesotrophic) with good water quality.

Information from the current monitoring project will be used to assess the longevity of the alum treatment's effect.

This report refers to two common measures used to predict water quality in lakes: the Trophic State Index or TSI (Carlson 1977), and the nitrogen to phosphorus ratio (N:P). The TSI and N:P ratios are calculated from the data collected through the volunteer monitoring program. TSI values are derived by a correlation that relates measured values of several parameters such as total phosphorus, chlorophyll *a* and Secchi transparency to estimated algal biovolume, rescaling the result to a range of 0 to 100. These numbers can be used to compare water quality over time and between lakes. Not enough data has been collected to date at Green Lake to verify an apparent trend statistically, but it appears that the lake is currently stable or even slightly decreasing in productivity over the short term.

The discussion in this report focuses on the 2009 water year and compares it to past years through the TSI indicators. Specific data used to generate the charts in this report can be downloaded from the King County Lake Stewardship data website at:

http://www.metrokc.gov/dnrp/wlr/water-resources/small-lakes/data/default.aspx.

Or can be provided in the form of excel files upon request.

Physical Parameters

Excellent precipitation and water level records were compiled for the 2009 water year. Water levels rose quickly in response to heavy or prolonged rain events during the period, which suggests that direct precipitation is important, and rainfall falling in the watershed flows quickly to the lake with limited infiltration. There were two sudden rises in lake level, one in July and one in September that were not directly preceded by precipitation events. These could be related to management activities by the Seattle Parks Department or Seattle Public Utilities, which are joined in responsibility for lake management. There is some variation in lake water level through the year, but the highest lake levels do not appear to persist very long (Figure 2).

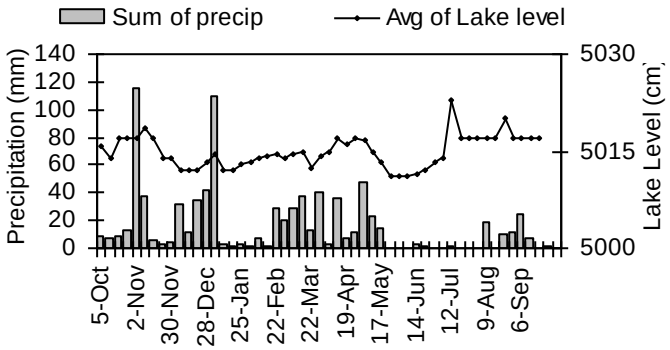

Figure 2: Green Lake Water Level and Precipitation

The students from Billings Middle School under supervision of their teachers collected physical data from the dock at East Green Lake throughout the year (see Figure 1). Volunteer monitors collected Secchi transparency and temperature data from early May

through late October at lake station Green-1 (over the deepest part of the lake) as part of the water sample collection routine.

Secchi transparencies at Green-1 ranged between 2.2 and 5.7 meters from May through October, averaging 3.7 meters (Figure 3), while the measurements made over the entire year from the dock ranged between 1.8 and 3.9m, averaging 3.3m over the entire year. However, the shallow water column at the dock site limited the depth to which the Secchi disk could be lowered, and the maximum depth is based on water depth rather than disappearance of the Secchi from view, which can bias the annual average towards a lower value. It is clear from the very slight variations found between November and May that the Secchi disk hit the bottom of the lake before disappearing on many occasions, thus providing a minimum value instead of the true value.

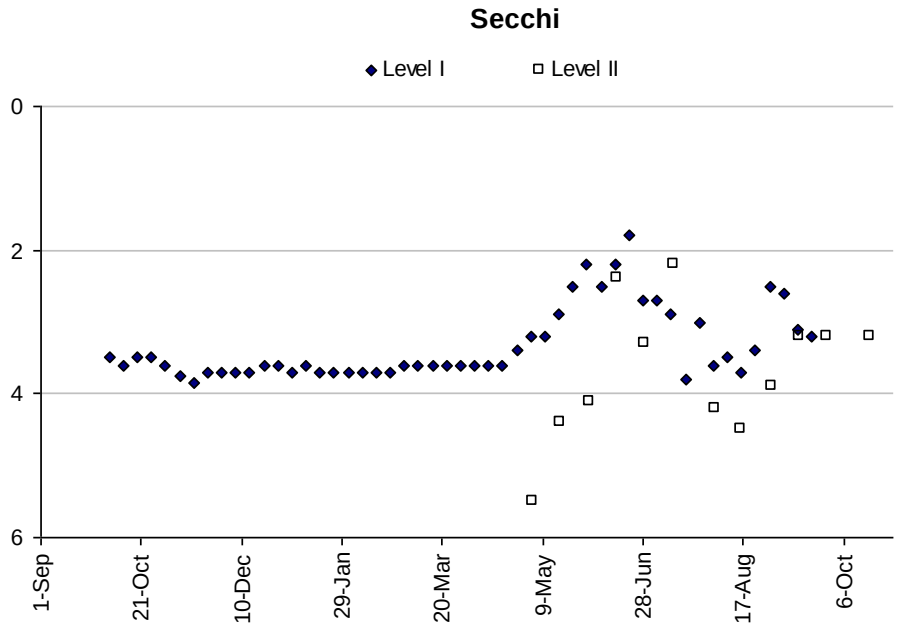

Figure 3. WY 2009 Green-1 and East Dock Secchi transparency

At station Green-1 surface water temperatures ranged between 13.0 and 26.0 degrees Celsius with an average temperature of 19.3 between May and October (Figure 4). At the East Dock, temperatures ranged from 3.0 to 25.0 degrees Celsius with an average of 11.7 over the entire year. Green Lake is in the lower range for summer maxima recorded among the lakes monitored in 2009.

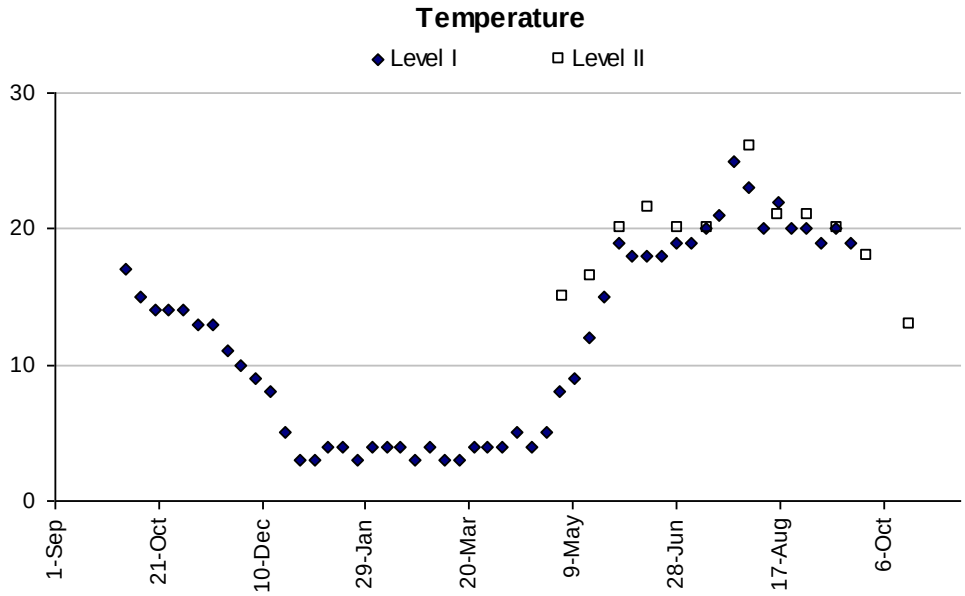

Figure 4. WY 2009 Green-1 and East Dock Temperatures

Nutrient and Chlorophyll Analysis

Phosphorus and nitrogen are naturally occurring elements necessary in small amounts for both plants and animals. However, many actions associated with residential development can increase concentrations of these nutrients beyond natural levels. In lakes of the Puget Sound lowlands, phosphorus is most often the nutrient in least supply; this means that biological productivity is often limited by the amount of phosphorus available for growth and reproduction. Increases in phosphorus concentrations can lead to more frequent and dense algae blooms – a nuisance to residents and lake users, and a potential safety threat if blooms become dominated by species that can produce toxins.

The alum treatment in 2004 at Green Lake limited the amount of phosphorus available by binding it tightly, thus keeping it from being taken up by growing algae. Since 2005, water quality samples collected by volunteers between May and October have been analyzed for total phosphorus (TP) and total nitrogen (TN) concentrations at one meter depth, with deeper water also sampled twice during the period each year.

At Green Lake-1 total phosphorus (TP) and total nitrogen (TN) did not vary greatly and remained fairly consistent through the sampling period (Figure 5).

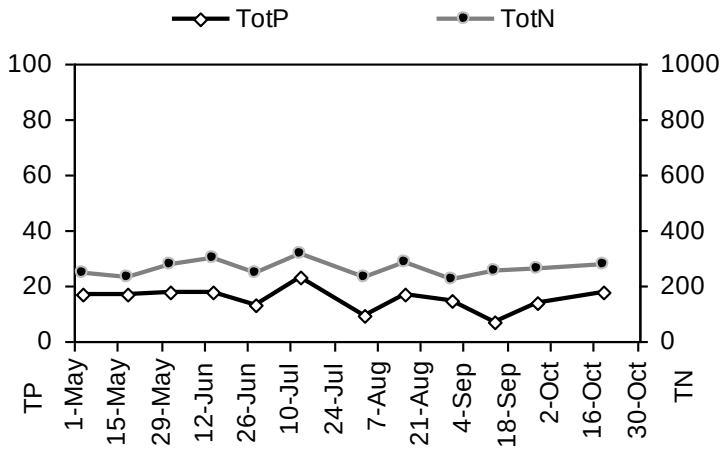

Figure 5. 2009 Green-1 Total Phosphorus and Total Nitrogen Concentrations

The ratio of nitrogen (N) to phosphorus (P) can be used to determine if conditions are favorable for the growth of cyanobacteria (bluegreen algae) that can impact beneficial uses of the lake. When N:P ratios are below 16 – 20, cyanobacteria often dominate the algal community due to their ability to take nitrogen directly from the air. Total phosphorus and total nitrogen ratios ranged from 13.6 to 34.4 with an average of 18.2, with only two dates having an N:P ratio above 20. This suggests that during much of the summer conditions may have been favorable for nuisance bluegreen growth in the lake, but the low concentration of available phosphorus kept the blooms from forming.

Chlorophyll *a* remained at low values with little variability through the entire sampling period at Green-1, consistent with low phosphorus availability. Pheophytin (degraded chlorophyll) remained below detection levels or barely detectable throughout the sampling season (Figure 6).

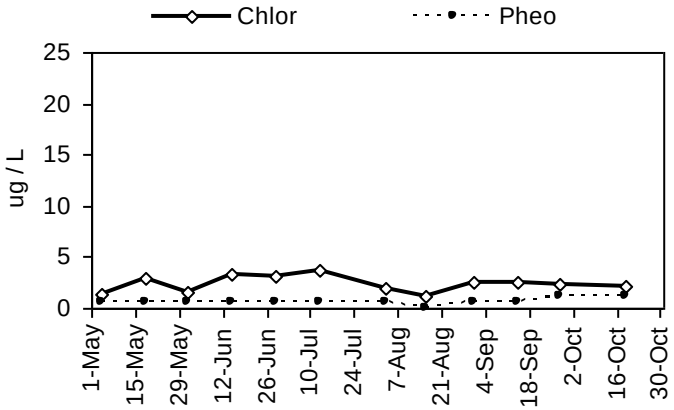

Figure 6. 2009 Green-1 Chlorophyll *a* and Pheophytin concentrations

Profile data (Table 1) from Green-1 indicate that the lake was fairly well mixed throughout the sampling season, though the May temperature profile suggests that a partial thermocline had developed at the time of sampling. However, no ammonia

accumulation was found in the deep water on either date, so thermocline development was most likely transitory, as it generally is in Green Lake. Concentrations of phosphorus in the deep water remained relatively low, showing no deep water retention from sediment release. Chlorophyll a data indicated that algae were equally distributed through the water column and were low in concentrations.

Table 1. Green-1 Profile Sample Analysis Results

Lake name	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NO2-3	NH3	Total P	OPO4	UV254	Total Alk
Green-1	5/18/09	4.4	1	16.5	2.9	<MDL	0.233	<MDL	<MDL	0.0171	<MDL	0.053	40.3
			3	16.0	2.2	<MDL	0.266			0.0148			
			6	14.5	1.7	1.2	0.262	<MDL	<MDL	0.0162	<MDL		
Green-1	8/31/09	3.9	1	21.0	2.6	<MDL	0.222	<MDL	0.007	0.0144	<MDL	0.067	45.2
			3	21.0	2.8	<MDL	0.244			0.0151			
			6	21.0	3.5	<MDL	0.284	<MDL	0.015	0.0233	<MDL		

The low values for UV254 indicate that the water of the lake is clear, with very little coloration from organic substances, while the total alkalinity values show that the water in the lake is relatively soft and lightly buffered from pH change. NOTE: In Table 1, <MDL stands for "below minimum detection level" of the analytical method.

TSI Ratings

A common method of tracking water quality trends in lakes is by calculating the "trophic state index" (TSI), developed by Robert Carlson in 1977. TSI indicators predict the biological productivity of the lake based on water clarity (Secchi) and concentrations of TP and chlorophyll *a*. At station Green-1 in 2009 the TSI-Chlorophyll indicator was in the upper range of oligotrophy, lower than the values for TSI-Secchi and TSI-TP just above the threshold for mesotrophy (Figure 7). These values have varied slightly from year to year since the alum treatment in 2004, but have shown no trend towards increase in algae productivity thus far and have remained consistently near the boundary between oligotrophy and mesotrophy (TSI value of 40).

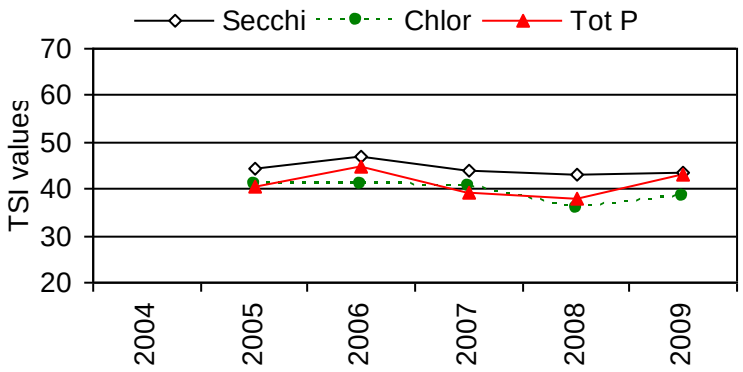

Figure 7. Green Lake-1 Trophic State Indicators

Conclusions and Recommendations

Based on monitoring data, water quality in Green Lake has been stable over the period measured since the alum treatment in 2004. The relatively low N:P ratios could indicate conditions are often favorable for bluegreen algae growth, but overall low levels of available phosphorus have likely kept blooms from forming.

Continued monitoring of nutrient and chlorophyll concentrations should be done to continue to assess conditions and verify trends, in particular to document the longevity of the effect of the 2005 alum treatment. Algae blooms at the lake should also be monitored, including submitting bloom or scum samples to the Washington State Department of Ecology's Toxic Algae Monitoring Program to determine whether or not blooms at the lake are producing toxins.